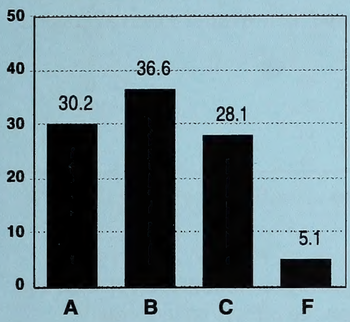
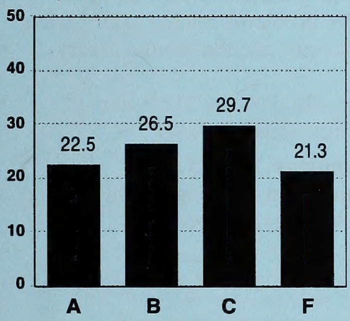
Physics 30

Diploma Examination Results
Examiners' Report for January 1996

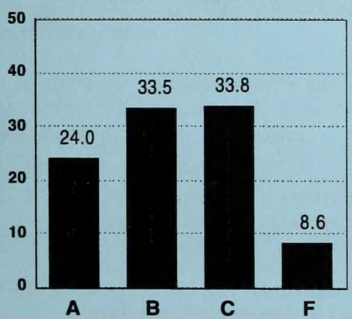
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the January 1996 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported is based on the final course marks achieved by 3 127 students in Alberta who wrote the January 1996 examination. This represents an increase of 256 students compared with January 1995 and is close to the number of students who wrote in January 1994.

- 91.4% of the 3 127 students achieved the acceptable standard (a final course mark of 50% or higher).
- 24.0% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Students demonstrated a good understanding of the course content and performed well in solving single- and multi-step problems that required calculations. Their ability to apply their understanding of Kirchoff's Laws has improved significantly. Students are, however, still experiencing some difficulty in clearly communicating the method they would use to solve the open-ended written-response problem. In addition, problems that involve algebraic manipulation of variables and derivations of formulas, which test the depth of the students' understanding of Physics 30 concepts, continue to cause difficulties for the majority of students.

Approximately 36.1% of the students who wrote the examination were female. Of these, about 92.6% achieved the acceptable standard on the examination, compared with 90.7% of the male population. Approximately 22.7% of this female population achieved the standard of excellence, compared with 24.8% of the male population. The average examination mark achieved by the female population (36.1%) was 62.7%, while the male population (63.9%) achieved an average mark of 64.9%.

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Provincial Averages

- The average school-awarded mark was 70.5%.
- The average diploma examination mark was 64.1%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.7%.

Approximately 8.7% of the students who wrote the examination in January 1996 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the January 1995 to January 1996 period. This sub-population (271) achieved an examination average of 59.2%, compared with 64.1% for the population (3 127) who first wrote a Physics 30 examination in January 1996. The group of student who rewrote (271) did not significantly change their overall exam averages.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Explain gravitational, electrical, and magnetic effects on systems
- GLE 2 Analyze and predict the behaviour and physical interactions of objects
- GLE 3 Describe and analyze resistive circuits and the function of EM devices
- GLE 4 Solve problems related to EM wave behaviour and the atomic theory

Skills:

- SPSC Scientific Process Skills and Communication Skills

Science, Technology, Society:

- STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC1	D	0.774		√			√	√
MC2	C	0.728		√			√	√
MC3	A	0.694		√			√	√
NR1	27.9	0.834		√			√	√
NR2	3.89*	0.818		√				
NR3	2.79**	0.757		√				
MC4	B	0.747		√			√	√
MC5	D	0.892		√				√
MC6	A	0.515		√				√
MC7	C	0.906		√			√	√
MC8	A	0.737		√				√
MC9	C	0.409		√			√	√
MC10	C	0.603	√					
MC11	A	0.642	√					
MC12	C	0.675	√				√	
NR4	3214	0.361		√			√	√
MC13	D	0.642		√				√
NR5	4.97	0.886						

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC14	B	0.564	√				√	√
MC15	A	0.897	√					
MC16	C	0.470	√				√	√
NR6	1.92	0.902		√				√
MC17	A	0.456	√				√	√
MC18	B	0.725		√				
NR7	1.65, 1.67	0.413		√				
MC19	A	0.752	√					
NR8	1.02	0.879				√	√	√
NR9	6.73, 6.74, 6.75, 6.76	0.864				√		√
MC20	D	0.776				√	√	
NR10	9.54	0.376				√	√	√
MC21	D	0.827			√		√	
MC22	A	0.705			√		√	
MC23	B	0.447			√		√	√
MC24	D	0.822				√	√	
MC25	C	0.737				√		√
NR11	9305, 93_5, 935_	0.561				√		
MC26	A	0.732				√		
MC27	B	0.377				√	√	
MC28	C	0.840				√		
MC29	B	0.921				√	√	
MC30	D	0.614				√		√
MC31	B	0.790				√		
MC32	B	0.422				√		√
MC33	B	0.861				√		
NR12	81	0.226				√	√	√
MC34	C	0.720				√		√
MC35	A	0.798				√	√	
MC36	D	0.810				√		
MC37	D	0.422				√		
WR1		0.690			√			
WR2		0.444		√			√	√

* The algorithm for all other accepted answers is NR2 = $(NR1)^2(5.00 \times 10^2)$; round, change to scientific notation, and compare to student's answer.

** The algorithm for all other accepted answers is NR3 = $(NR1)(1.00 \times 10^3)$; round, change to scientific notation, and compare to student's answer.

*** The algorithm for all other accepted answers is NR9 = $(NR8)(6.63 \times 10^{-34})$; round, change to scientific notation, and compare to student's answer.

Subtest: Multiple Choice, Numerical Response, and Written Response

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

General Learner Expectations:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems	5.1	out of	8
GLE 2	Analyze and predict the behaviour and physical interactions of objects	16.5	out of	28
GLE 3	Describe and analyze resistive circuits and the function of EM devices	8.9	out of	13
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	14.4	out of	21
Skills	Scientific process and communication skills	16.5	out of	26
STS	Connections in science, technology, and society	19.6	out of	35

- Multiple choice and numerical response: 33.3 out of 49
  Multiple choice: 25.4 out of 37
  Numerical response: 7.9 out of 12
- Written Response: 11.5 out of 21
  Question 1: 6.9 out of 10
  Question 2: 4.4* out of 11
  Communication: 1.6 out of 3
  Content: 2.9 out of 8

* Individual student scores for Question 2 are equal to the Scale 1 score added to the Scale 2 score, then rounded to a whole number before calculating the final average raw score for Question 2.

The following questions were selected for discussion because they exemplify what is required to meet the acceptable standard and the standard of excellence.

Five cars were used in a test designed to study how injuries to the occupants of a car could be reduced.

Car	Mass (kg)
1	1740
2	2950
3	1770
4	2000
5	2040

4. Each car was designed with energy-absorbing crumple zones. Car 4, travelling at 100 km/h (27.8 m/s), was crashed into a wall and became 0.500 m shorter during impact. The average retarding force was

A. 1.36×10^6 N
•B. 1.54×10^6 N
C. 1.57×10^6 N
D. 2.36×10^6 N

Multiple-choice question 4: Most students (74.7%) were able to interpret the information presented in the context of the study described and to recognize that in order to solve the problem, they needed to apply their knowledge of conservation of energy to calculate the retarding force on the car. Students supported their understanding of physics by successfully applying their computational skills to arrive at the correct mathematical solution.

Of the students who achieved the standard of excellence, 93.9% answered the question correctly, and of those students who achieved the acceptable standard but not the standard of excellence, 71.8% answered correctly. In addition, 43.9% of the students who did not achieve the acceptable standard chose the correct answer.

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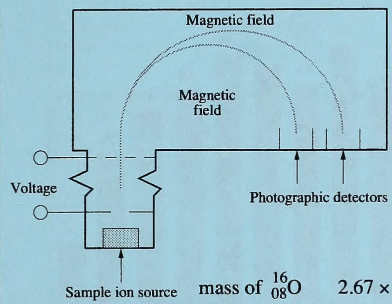
6. The 1740 kg car travelling north on an icy test area was crashed into the 2000 kg car travelling west. The test designers found that the two vehicles locked together on impact and slid at 9.0 m/s at 35° west of north. What was the speed of the 1740 kg car just before impact?

•A. 16 m/s
B. 11 m/s
C. 8.5 m/s
D. 5.9 m/s

Multiple-choice question 6: To successfully answer this question, students needed to apply their knowledge of conservation of momentum and their knowledge of two-dimensional collisions. Most students realized that the momentum before and after the collision remained constant, but many students experienced difficulties in resolving the resultant vector into its northerly and westerly components. Many students recognized the need to use trigonometry to solve the problem, but they were either unable to draw the correct vector diagram or used the wrong trigonometric function in their solution. Correctly applying trigonometry to solutions of two-dimensional momentum problems continues to be a significant problem for many of the students who do not achieve the standard of excellence. As more questions related to non-linear, two-dimensional situations are developed by teachers and are placed on diploma exams, student achievement in this area is expected to improve.

On this question, 77.4% of the students who achieved the standard of excellence calculated the correct answer, while only 44.5% of those students achieving the acceptable standard but not the standard of excellence were able to successfully complete the question. Only 33.5% of the students who failed to attain the acceptable standard answered this question correctly.

There are two stable isotopes of oxygen, ${}^{16}_{8}O$ and ${}^{18}_{8}O$. The ratio of ${}^{16}_{8}O$ to ${}^{18}_{8}O$ in the ice of ancient glaciers is an indication of past temperatures. A mass spectrometer is used to measure the numbers of ${}^{16}_{8}O$ and ${}^{18}_{8}O$ atoms in a sample of ice. It uses a potential difference to accelerate the oxygen ions (O^{2-}) in a straight line. The path of the ions is then bent into circular motion by a magnetic field.



mass of ${}^{16}_{8}O$	2.67×10^{-26} kg
magnetic field	1.01×10^{-1} T

Numerical Response

7. The radius of the path for ${}^{16}_{8}O^{2-}$ ions that are moving at a speed of 2.00×10^{5} m/s, expressed in scientific notation, is $b \times 10^{-w}$ m. The value of b is __________.
(Round and record your answer to three digits.)

Answer: **1.65, 1.67**

A Japanese car manufacturer is designing an automatic braking system that detects objects in a car's path. The system involves a detector that receives reflected laser signals.

. A signal sent by the laser is reflected and returned to the detector 0.15 µs after its transmission. The distance from the car to the detected object is

A. 15 m
•B. 23 m
C. 42 m
D. 45 m

Numerical Response

12. A 0.050 MeV X-ray beam is used to take a child's chest X-ray. The child's chest is 9 cm thick and the half-distance for this radiation in body tissue is 3 cm. The ratio of the energy received by the chest surface to the energy received by the skin on the child's back is a to b.

(Record your answer as $\boxed{a}\boxed{b}\boxed{\ }\boxed{\ }$)

Answer: **81**

Numerical-response question 7: This question required students to recognize, from the context, that the forces causing the particles to move in a circular orbit are equal ($F_{cent} = F_{mag}$). Students then needed to derive an equation and make the appropriate substitutions to solve for the radius. Some students who were able to derive the correct equation made the incorrect assumption that the charge on the ${}^{16}_{8}O^{2-}$ ions was 1.6×10^{-19} C. This resulted in an incorrect solution. As students gain more experience with deriving equations and working from within a context, achievement on this type of question will improve. On this question, 79.4% of the students who achieved the standard of excellence were successful in arriving at the correct solution. Of the students achieving the acceptable standard but not the standard of excellence, 32.8% obtained the correct answer, and only 2.2% of those students who failed to achieve the acceptable standard had a correct solution.

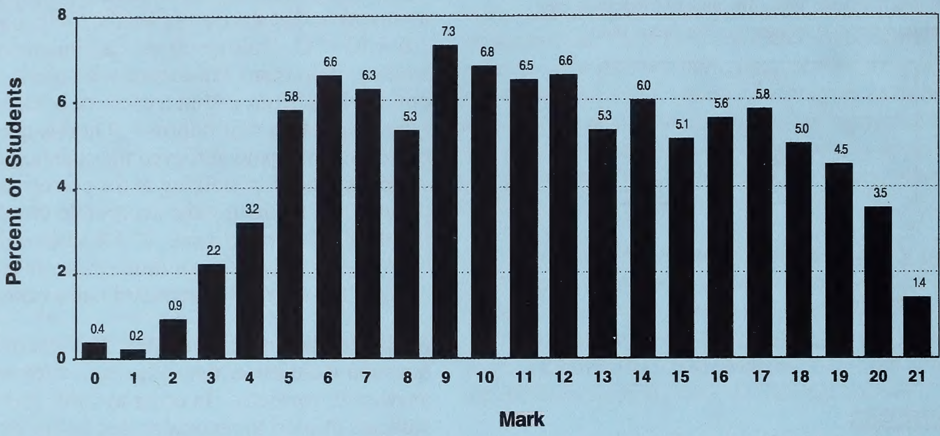
Multiple-choice question 32: The results on this question were lower than expected, with only 42.2% answering correctly. In order to solve this question, students needed to recognize that lasers are a form of electromagnetic radiation and, therefore, travel at the speed of light. Students were then required to use their knowledge of the relationship between distance, velocity, and time to calculate the required distance. The factor that discriminates between students at various levels is whether or not they recognize that the laser beam travels to the car and back in the time indicated. Of the students who achieved the standard of excellence, 70.1% correctly solved this problem, while only 35.7% of those students who achieved the acceptable standard but not the standard of excellence successfully answered the question. Alternative D was chosen by 46.6% of all students answering the question.

Numerical-response question 12: Student success on this question was lower than expected, with only 22.6% of the students answering correctly. Students needed to understand that X-ray penetration is analogous to radioactive decay and that this is a "half-life" question. Even students who were able to recognize the nature of the problem often stated a ratio of 3 to 1 or 6 to 1, rather than 8 to 1, indicating that they do not understand the exponential nature of radioactive decay. Many students who solved the question correctly stated their ratio incorrectly (i.e., 1 to 8 instead of 8 to 1). Of the students who achieved the standard of excellence, 52.7% answered correctly, while only 14.6% of those who achieved the acceptable standard but not the standard of excellence were able to find a correct solution. Only 1.9% of those students who did not meet the acceptable standard answered the question correctly.

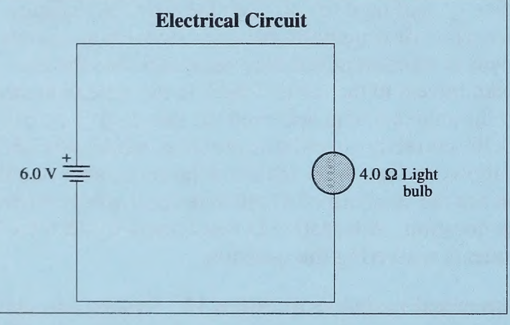
Written-Response Questions

Of all the students who wrote the exam, 55.2% received a mark of 11 or higher out of 21. The average mark on the written-response questions was 11.5 or 54.7%.

Distribution of Marks for Written Response



Written Response – 10 marks



1. **a.** On the diagram above, correctly place and label the following six items. Show any additional wiring that is required to complete the circuit.

- a 3.0 Ω bulb in parallel with the 4.0 Ω bulb
- a 5.0 Ω bulb in series with both the 3.0 Ω and 4.0 Ω bulbs
- a switch to control the whole circuit
- a switch to control the 3.0 Ω bulb only
- a voltmeter to measure the potential difference across the 5.0 Ω bulb
- an ammeter to show the current passing through the 3.0 Ω bulb

b. Determine the total resistance of the circuit after the addition of these six items. Assume the switches are closed. (Show all the steps to your solution.)

c. Calculate the voltmeter reading across the 5.0 Ω bulb. (Show all the steps to your solution.)

d. Calculate the ammeter reading for the current passing through the 3.0 Ω bulb. (Show all the steps to your solution.)

Written-response question 1 was well answered. Students were required to place six items on a circuit diagram and to label it correctly. Most students did this. Students who placed the 5Ω resistor between th 4Ω and 3Ω resistors significantly complicated their calculations in subsequent parts of the question. The scoring of parts b, c, and d was based on the circuit diagram drawn by the student, or a correct solution based on Kirchoff's Laws (whichever gave the studer the highest mark). Students who gave a solution wit all resistors in series or all resistors in parallel could earn a maximum of 7 out of 10 marks on this questio Students demonstrated a good level of understanding of the relationships among current, voltage, and resistance. In many cases, the students who had just achieved the acceptable standard drew circuit diagrar that did not correctly place the ammeter in series and the voltmeter in parallel.

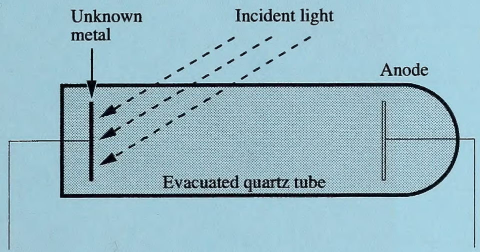
Of the students who achieved the standard of excellence on the exam, 79.2% received 8 out of 10 c better on this question.

On this question, 93.6% of the students who achievec the acceptable standard on the exam received a 5 out 10 or better.

On this 10-mark question, the average mark was 6.9 c 69.0%.

Written Response – 11 marks

The labels have fallen off two evacuated tubes that have unknown metals at each cathode. One tube, with Metal X as its cathode, detects visible light leakage from cameras. The other tube, with Metal Y as its cathode, detects ultraviolet leakage from shielded equipment. A student needs to know which tube is which. One of the evacuated tubes are shown below.



Also available is a variable-frequency electromagnetic wave source, a variable voltage source, a voltmeter, and any reference tables needed.

Design an experiment using the photoelectric effect to distinguish between Metal X and Metal Y. Your experimental design must contain:

- Statement of the purpose of the experiment
- List of the equipment needed
- A complete labelled diagram (above) of all the equipment necessary
- Procedure
- Measurements to be made and recorded, and any tables necessary
- Description of the analysis to be done
- An explanation using either the calculation or the derived algebraic equation showing how it will be used to distinguish between Metal X and Metal Y.

Note: A maximum of 8 marks will be awarded for the physics used in your design. A maximum of 3 marks will be awarded for the effective communication of your response.

Written-response question 2 was not as well answered as expected. Students were required to design an experiment that would demonstrate their understanding of the photoelectric effect. To obtain full marks, students needed to establish an experimental design, develop a procedure that supported this design, and provide an analysis and/or explanation of their findings.

Students who did not measure stopping voltage could still earn full marks. They were not required to demonstrate knowledge of all the associated formulas, but they were required to provide a thorough explanation of their results.

In general, students were aware that determining the threshold frequency was the key element in identifying the evacuated tubes. The difficulties arose in clearly communicating a consistent experimental design, procedure, and analysis. Many students felt their design was limited by the equipment listed in the question and, to accommodate this, they used the voltmeter to measure the presence of current. In cases where this occurred, and the remainder of the solution demonstrated a thorough understanding of the photoelectric effect, students were awarded 10 out of 11 marks.

Students who demonstrated some knowledge of experimental design, even if the content was unrelated to the question, received partial marks for communication.

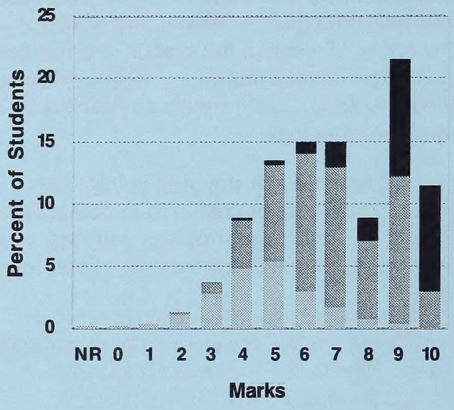
Students who scored 0 out of 8 for content demonstrated no understanding of the photoelectric effect and, in many cases, designed experiments that were totally unrelated to the question (e.g., measurement of the speed of light, or the operation of a gas discharge tube.)

The most significant reason for the poor results on this question was that 30.9% of the students received 0 out of 8 marks for physics content. Of these students, 57.1% also failed to meet the acceptable standard on the diploma exam. Of the students who achieved the standard of excellence on the exam, 65.8% received a grade of 6 out of 8, or better, for physics content.

On this 11-mark question, the average mark was 4.4 or 40%.

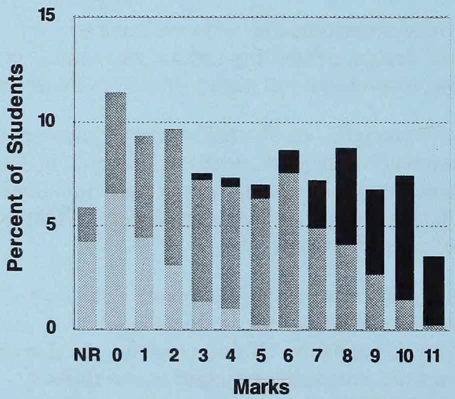
For further information, contact Corinne McCabe or Yvonne Johnson at the Student Evaluation Branch, 403-427-0010.

Distribution of Marks for Question 1



- Standard of Excellence on the Examination
- Acceptable but not Standard of Excellence on the Examination
- Below Standard on the Examination

Distribution of Marks for Question 2



- Standard of Excellence on the Examination
- Acceptable but not Standard of Excellence on the Examination
- Below Standard on the Examination